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Innovation, Markets, and Evolution

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Abstract:

This paper approaches innovation from an evolutionary perspective. Literature spanning a broad range of traditions in economics is considered, to include Institutionalist, Schumpeterian, post-Keynesian, and growth theorists. Key systemic changes are examined in the context of prevailing technological and social institutions. It is argued that e*xpectation-fixing* effects such as path-dependence in investment and innovation provide structure to a social network of market institutions that seek to validate money contracts. The institution of money is considered as a center of power in the system and affects the course of innovation. Money as the unit of account becomes the object of desire in a system of monetary production.

Introduction

Robert Heilbroner's description of economics as *The Worldly Philosophy* could not be more insightful. For Heilbroner, economics presents a system of thought that seeks to categorize and explain the behavior not of heavenly gods, but rather worldly men. The "propensity to truck, barter and trade[1]" reflects the being which must apply clever tricks to avoid the cold indifference of nature. In this way, economics is inextricably linked to the study of human ingenuity. This unique trait has allowed *Homo sapiens* to bend the constraints of its physical environment. Unlike any other species, which evolve as a whole population through a stochastic process of natural selection with respect to a particular habitat, humans apply learned techniques in an effort to change conditions to fit the needs of the group, and by extension the species. As well as *passive* adaptation through variation in offspring, humans possess the art of tool manipulation – an *active* process that increases the likelihood of group survival. Anthropological evidence confirms the importance of innovation in techniques through cultural artifacts, placing innovation at the center of humanity.

This paper seeks to explain key aspects of the role of innovation in the history of economic thought, with a particular focus on money as both a force that shapes the evolution of dynamic processes and the object of inventive activity. Moreover, this inquiry strives to further our understanding of innovation through an analysis of its linkages to the economic processes which drive systemic evolution. In a world where time flows in only one causal direction, changes in technology today forever alter the future conditions that underlie a large economic system. Further, changes reverberate throughout the system in an ongoing process of *cumulative causation*, creating a non-

1 Adam Smith, An Inquiry into Nature and Causes of the Wealth of Nations

deterministic future highly sensitive to the initial conditions of the emergent state. The concept of cumulative causation is a key insight into the dynamic, evolutionary nature of economic systems, which institutional economists have brought to high level of refinement. Thorstein Veblen in, "Why is Economics Not an Evolutionary Science?" (1898, pg. 139) frames the problem at hand:

> "The ways and means, material and immaterial, by which the native proclivities work out their ends, therefore, are forever in a process of change, being conditioned by the changes cumulatively going forward in the institutional fabric of habitual elements that govern the scheme of life."

Hall and Whybrow (2008) argue that Veblen's emphasis on the interplay between the "material and immaterial" reconciles economics as a science with the philosophy of evolutionary change[2].

The importance of a new technique, tool or process within the larger cultural and social milieu is of profound interest if we are to reconcile notions of progress and change in terms of the market. Veblen again makes this point in his own words:

> "What is true of the individual in this respect is true of the group in which he lives. All economic change is a change in the economic community – a change in the community's methods of turning material things to account. The change is always in the last resort a change in habits of thought. A given contrivance for effecting certain material ends becomes a circumstance which affects the further growth of habits of thought – habitual methods of procedure – and so becomes a point of departure for further development of methods of compassing the ends sought and for the further variation of ends that are sought to be compassed."

Veblen shows that innovation in the "community's methods of "*turning material things to account* "(italics added for emphasis) – a change in the mode of production *per se* – results in an

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[2] Hall and Whybrow connect Veblen's conception of cumulative causation with the synechist approach C.S. Peirce, a father of the Pragmatist School.

alteration of society's institutional "habits of thought." Moreover, these changes set the stage for a permanent departure from the present state. From here we may envisage innovation in its larger, evolutionary societal context.

This analysis draws upon the insights of several schools of thought within the economics discipline in order to establish a framework capable of integrating innovation into the large set of economic processes. We begin with the recognition that economic systems evolve over time in a process which remains non-teleological in nature. In other words, we are concerned with a system that changes through time based upon the cumulative interaction of its constituent elements, steered through time by historical precedent, not by rational conceptions of natural, immutable states of equilibrium. Historical events -*themselves the consequence of an earlier set of conditions* — serve to shape the nature of emergent states. The interplay between the present situation constrained both by the physical world and social institutions, and the reaction of the same in the form of innovation, reverberate in a feedback loop of causality. The evolutionary conception of change places innovation in a dual role as both a reflection of the violence of social change and cause for further adaptation.

An evolutionary approach to innovation must consider the contribution of Joseph Schumpeter on the subject of the business cycle. Schumpeter's (1934) seminal work *The Theory of Economic Development* embeds innovation within a larger, evolutionary context that seeks to account for the dynamic forces that provide the bittersweet *creative destruction* of progress. Schumpeter (1934, pg. 58) argues the emergent state of an economic system must be understood in terms of the previous state of the entire system, not just those elements commonly regarded as economic. The force for Schumpeterian change springs forth from innovations made successful by the entrepreneur, accounting for the change in the business cycle along with a new era of investment activity. Through new

combinations of technique and finance, innovations emerge to *reshape* the circular flow of resources economy wide.

As Schumpeter (1934, pg. 64) meticulously stresses, the processes working to *reshape* the circular flow of the economy emerge *endogenously* from within the system. While defining economic development, Schumpeter leaves us with this famous insight into the cumulative effect of endogenous change:

> "...what we are about to consider is that kind of change arising from within the system and *which so displaces its equilibrium point that the new one cannot be reached from the old one by infinitesimal steps.* Add successively as many mail coaches as you please, you will never get a railway thereby." (author's italics)

Thus, Schumpeter lays out the importance of uncertainty and time in explaining economic change. The inherent complexity in the social system of production suggests an infinite range of possible emergent states, all distinctly representative of innovations upon the original state. Therefore, accidents of history which led to, for example, the development of the key constituents of railroad technology – e.g. steel production, the steam engine, eminent domain – jointly determine the path of innovation. Successive improvement and diffusion of the mail coach does not imply convergence towards the railroad.

In order to conceptualize the dynamic processes affecting the manner and nature of innovation through history, we employ the Social System of Accumulation framework developed within the recent n*eo-Marxist* literature. Emanating from the seminal work of David Gordon, Richard Edwards and Michael Reich (1982), Social Structure of Accumulation (hereafter SSA) theory attempts to explain long-wave cycles of capitalist history. SSA theory points to distinct periods of accumulation and

stagnation to a holistic arrangement of institutional factors, which provide periods of relative stability. Moreover, the particular network of institutional factors which constitute the SSA break down over time, giving way to a period of stagnation and the dissolution of that particular structure. As the market undergoes a new period of expansion and accumulation, a new SSA emerges to carry on in a new period of relative stability.

Additionally, our analysis integrates the role of money in the form and function of the SSA as a stabilizing set of institutions. This approach adopts the post-Keynesian (PK) formulation of *endogenous money theory (EMT)*, which presents a systematic approach to explaining how flows of credit money through the economy affect production. While we touch on some of the key concepts of EMT in our treatment of innovation under the organizing effect of a SSA, a thorough exposition of the heterodox theory of money shall be dealt with in Part 4.

Traditionally, mainstream economics takes a narrow view of the importance of innovation in accounting for growth and change. This is not to suggest that orthodoxy ignores the effect of innovation on economic change, only that they hold technological change as separate from the material lives of human beings and their overall relation with the production process. This distinction relegates innovation as an exogenous effect on the larger economic system. In contemporary literature, innovation results in changes in total factor productivity, so that processes that account for changes in the production process are lost in the "black box" of the residual to the two pillars of growth that are capital and labor. While efforts have been made to break open the "black box" of innovation, much of the importance of the innovation process itself has been ignored. However, recent research in the literature that focuses on innovation offers promise for new revelations on the endogeneity of innovation led growth.

Despite the reluctance to embrace an evolutionary approach to methodology, neoclassical growth literature has produced a robust and wide-ranging body of knowledge pertaining to the determinants of the Industrial Revolution. Several explanations seeking to establish a causal foundation for the onset and timing of the Industrial Revolution are considered within the growth literature, such as the role of religion and history.

Joel Mokyr provides a framework for understanding the process of innovation from an epistemological approach. Mokyr proposes that changes in technology result from an interplay between *propositional knowledge* and *prescriptive knowledge*. Mokyr defines propositional knowledge as the set of all "useful information," to include science, philosophy, religion and other habits of thought. Essentially, propositional knowledge serves to create an epistemological basis for culture;A ready pool of insight into future contemplation. Prescriptive knowledge refers to information relating to technique. The production of flour via the windmill serves as an example of prescriptive knowledge. Knowledge that the windmill operates in accordance with the weather can be categorized as propositional knowledge. The distinction lies in applicability.

Part one of this paper explores the role of innovation in bringing about the Industrial Revolution, as an example of an era of innovation to which economists have paid a great deal of attention. Through Mokyr's framework we divide the Industrial Revolution into periods possessing distinct relations between propositional and prescriptive knowledge. First we show that inventions prior to 1800 were characteristic of an era that lacked the epistemic maturity to embrace innovation as an integral process in the economic system. Mokyr points out, often inventions emerged despite a lack of understanding of its fundamental, physical properties. Following 1800, advances in the natural sciences allowed for a wider base of knowledge enabling innovation based upon deliberate, scientific

engineering.

In addition to the emergence of major technological innovation, the Industrial Revolution hosted cultural innovation through institutional change. Central changes include the emergence of legal establishing well-defined property rights, and the enforcement of contract. The emergence of the factory as an organizing principle in society becomes an important determinant of change. Additionally, the factory creates a demand for capital intensive innovation.

In part two we introduce SSA Theory. We shall argue that SSAs serve to stabilize expectations of firms with regard to the future determination of prices and profits, allowing sophisticated planning at the organizational level. Contrary to the notion that firms simply respond to the sovereign will of the consumer through market signals, which holds for production of simple, low tech commodities for the market during the *Laissez Faire* era, the behavior of firms in the wake of the Industrial Revolution suggests the need to orchestrate production to reflect perceived conditions in the future. The Industrial Revolution brought to bear on the market the sort of innovations – e.g. the railroad, electrical production, etc. - which heralded an age of goods produced using large-scale heavy capital. Capital intensive production implies a considerable degree of risk which must be attenuated in order to induce investment well ahead of prospective profits.

We shall explore the connections between the institutionally determined, *expectations-fixing effects* consistent with the SSA approach as well as the post-Keynesian conception of endogenous money theory, in order to explain the nature of innovation during the 20th Century[3]. It shall be argued that the result is a tendency towards path-dependence in investment and capital formation.

In part three of this inquiry we examine institutional innovation, in light of the philosophical

[3] Here I propose expectations-fixing to be a quality of certain effects, devices or techniques which stabilize the outlook of an uncertain future.

insights of John Dewey and the theoretical implications of *path-dependence*, as it relates to social milieu. The central argument of this section is the notion that institutional innovation results in an asymmetrical distribution of effective power within social networks[4], resulting in a nexus of rigid institutions that seek to preserve the existing order. We shall examine this effect and discuss some of the central challenges of technological improvements that make possible further access to the social network, in the absence of requisite institutional adaptation.

Part 4 examines the role money plays in a market economy and its effect on innovation. The post-Keynesian conception of money starts with a rejection of the *Quantity Theory of Money (QTM)*. Chief proponents of this approach argue that the QTM is suitable merely as an accounting tool to measure in money terms what is essentially a barter economy. Since the market is not a barter economy, but rather a monetary economy, the central tenet of the QTM - *the supposed neutrality of money principle* - fails to hold. In a monetary system of production, nominal interest rates matter, as well as the means by which liquidity is supplied to those requiring it.

Money plays a special role in the larger study of innovation through history of our socio-economic system, where major innovations enter the market through the creation of credit and the establishment of forward contracts based upon expected flows of revenue. This thesis argues that money is the most important institution in a social system that organizes production and distribution through market based institutions. L. Randall Wray (2006, pg. 185) points to a key revelation by Keynes that a central determinant of the manner in which money flows through the economy, stems from the uneasiness implied by an uncertain future; possession of cold, hard cash "lulls our

[4] Effective power in this case refers to the relative influence a central node exerts over the network.

disquietude." In turn the rate of return on an asset that requires one to surrender that liquidity, offers some base indication of the level of anxiety associated with the possibility that unforeseen events will render the investor insolvent.

At an economy wide scale, the cumulative effect of individual desires to hoard money may prevent investment at levels that fully employ the resources of the economy. Under these conditions, the scope and nature of innovation and its diffusion through the economy reflects the desire to create inventive ways of ensuring a necessary level of liquidity to validate liability structures through the time schedule of a set of annuities. Once money reaches a stage of institutional primacy, it undergoes a process of innovation as it evolves under the influence of the market demand for liquidity.

Part 1: Innovation During the Industrial Revolution

Economists have long pondered the questions: Why did the Industrial Revolution occur when it did, and for what reason? Several schools of thought have sought to solve the problem. Mokyr (1985, pp. 3-5) identifies four schools of thought on the subject of the Industrial Revolution: The Social Change School, Industrial Organization School, Macroeconomic School, and the Technological School. We shall briefly example each approach in turn. The Social Change School emphasize the role of major institutional shifts in bringing about conditions amenable to market production. The emergence of the market itself ushered provided conditions of the burst of innovation typical of the Industrial Revolution. Second, The Industrial Organization School argues that size and scale of the firm in the pursuit of industrial production was a key determinant during the period. Mokyr suggests that the Macroeconomic School follows in the tradition of Kuznets through their emphasis on aggregate variable. While this study is concerned with macro-effects of innovation on social change we are less concerned with aggregate macro variables here. Lastly, the Technological School suggests that changes in technique account the period of magnificent innovation.

More broadly we argue that an epistemological approach explains the processes characteristic of major systemic change. The aim of this section is to analyze the Industrial Revolution in terms of the innovative process. The innovative process consists of the interplay between *propositional knowledge*[5] and *prescriptive knowledge*[6], where the former provides an *epistemic base*[7] by which the

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[5] Set of all knowledge held of science, myth, philosophy, etc.

[6] The information describing a technique or set of instructions. An invention is a new element of prescriptive knowledge.

[7] Epistemic base refers to the scope of a knowledge within a social network.

latter may rest. This base can be thought of as a measure of certainty in adopting a new technique. Additionally, the "width" of the epistemic base implies a level of cost in its accession as well as the reliability of the technique. It is argued that Mokyr's knowledge framework effectively shows the dynamic nature of innovation during the Industrial Revolution.

Mokyr divides the Industrial Revolution into two distinct periods: Pre and post 1800. The former is regarded as period in which the epistemic base of propositional knowledge was insufficient in providing emergent prescriptive knowledge an environment where it might gain permanence. As a result many micro-innovations lacked a necessary level of diffusion required to become a stable part of the system. Likewise, Mokyr argues that innovations emerging in the latter period found stability in respectively wider epistemic bases, allowing for wider diffusion of the knowledge embodied in emergent technique.

We shall consider both periods of innovation as presented by Joel Mokyr in the context of the Industrial Revolution. Additionally, we attempt to describe the role of culture in determining the rate of innovation.

Innovation prior to 1800

Before 1800 the base of propositional knowledge was too narrow to support the widespread diffusion of many innovations. Mokyr (2002, pg. 19) argues that innovations in technique prior to 1800 typically lack a sufficiently large base of awareness in science and philosophy to support its sustained implementation. More specifically, the reliability of propositional knowledge and its ability to correctly evaluate the performance of a technique had not yet reached the level required to develop the *type* of innovation likely to invite further, sustained and responsive micro-innovation. In other words,

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Narrow implies majority ignorance of some possible knowledge.

in the absence of a solid working set of useful knowledge of the governing forces of the natural world, a technique would likely fail to invite further improvements, due to a lack of understanding of the practical nature of the innovation in the first place. Additionally, with a limited epistemic base for a particular innovation, non-scientific attempts frequently yielded negative, costly results.

In an uncertain world where people must hedge against an unknowable future, "tightness" of knowledge in the propositional base serves to attenuate the perception of risk. As the gains in science are proven in marvelous of human engineering, the reliability of propositional knowledge increases. In a market economy liquidity is required to secure the desired flow of resources for consumption or production needs. Therefore, any commitment of resources to an endeavor – such as undertaking process innovation – carries a degree of risk that the outcome of the application of the innovation might result in a failure to increase productivity, thereby rendering it difficult to maintain the desired level of liquidity. An innovation in technique is always an undertaking involving a considerable degree of risk, since the extant set of techniques remains ready for combination with the capital instead committed to innovation.

The Industrial Revolution rests on the shoulders of what Mokyr (2002, pg. 35) defines as the *Industrial Enlightenment.* The *Industrial Enlightenment* can be described as those elements of the Enlightenment that account for an expansion to the set of knowledge practical for the pursuit of industry. Mokyr (2002, pg. 84) points to advances in thermodynamics, geology, mechanics, hydraulics, electromagnetism, and soil science as elements of the Industrial Enlightenment. Further, Mokyr (2002, pg. 37) suggests that the spillover effects from scientific activity during the period created a culture, mindset and set of methods all embodied in the pursuit of science, thrusting knowledge into the public domain. The collaborative, peer-reviewed nature of the scientific method serves to make the claims of

the scientist public, resulting in the creation of a public good from the scientific process. As a non-depleting good the access costs of scientific information diffused more rapidly throughout communication networks, swelling the epistemic base for future technological evolution.

Communication networks emerged to connect scientific ideas to the minds of practical engineers. In response to the advances in the natural sciences, Mokyr (2002, pg. 45) argues that there was a growing urge to share the information freely. Institutions such as *The Society of Arts* in 1754 and the Royal Institute in 1799, serve as examples of efforts to take knowledge and place it in the public domain. These institutions performed the function of reconciling science with common experience through language and expression. The presentation of scientific findings takes on a role of cultural significance; the ritual becomes the basis by which the fidelity of subsequent innovation rests. Additionally, standardization in measurement and mathematical precision allowed scientists to collaboratively engage in inquiry within networks capable of further diffusion.

Innovation post 1800

Increases in the vast library of propositional knowledge following 1800 marks a change in the process of innovation. Beginning in 1860 what Mokyr (2002, pg. 85) calls the Second Industrial Revolution frames a period of where innovation was the result of deliberate, applied science. The techniques had the advantage of tight epistemic bases resulting in sustained micro-innovation. Major innovations were now possible in light of advancements in the physical sciences and mathematics. Furthermore, wider diffusion of innovations are possible thanks to the billowing effect of the presentation of scientific proceedings in the public forum.

Major innovations were made possible by a widened base of propositional knowledge. Mokyr (2002, pg. 86) offers as a prime example the Bessemer process of 1856. By then advancements in

chemistry were sufficient to provide Henry Bessemer, and other process innovators, with the insight to identify the causal linkages present in the very techniques under experimentation. While Bessemer's approach did not start with the goal of adjusting the carbon content to produce steel, he certainly recognized that it his blasting process was responsible for achieving the desired results. Moreover, Mokyr (1990, pg. 116) highlights the importance of the broad base of *available* knowledge as a determinant in the ongoing evolution of an emergent technique, by pointing to the refinement of Bessemer's process by the British steelmaker Robert Mushet. Accessible knowledge in chemistry allowed Mushet to discover that an alloy of manganese, iron, and molten ore served as a recarburizer, adding much needed quality to the cheap steel developed with the Bessemer process.

In similar fashion, refinements in thermodynamics allowed engineers to understand *how* the engine worked, not simply that it did. Mokyr (2002, pg. 87) suggests that successful development of a new technique does not require understanding into the physical properties:

"Good mechanical intuition coupled to a sound experimental method was, up to a point, a good substitute for formal science and helped James Watt to transform a crude and clumsy contraption into a universal source of industrial power...But the epistemic base that could help analyze and explain the efficiency of such engines did not exist. John Farey, the best expositor of the steam engine, still regarded the steam engine in 1827 as a vapor-pressure engine rather than a heat engine."

The ability during this era to understand the fundamental aspects of a physical process meant that the technician, inventor, scientist or engineer could actually approach a problem with an informed opinion about the future results of their experimentation. The lens of ingenuity came into focus.

As a result, further improvements in engine design led to breakthrough levels of efficiency, power and adoption in other industrial applications. Engines were notoriously inefficient prior to

Watt's improvements. Von Tunzelmann et al(2000, pg. 193) attribute the price of coal as a major determining factor in the diffusion of steam engines, resulting in geographical adoption patterns which placed the Newcomen engine near cheap coal. Indeed, until subsequent efficiency boosting micro-innovations, the steam engine remained co-located with coal mines that both fueled the engine and required its pumping service. As engines increased in fuel efficiency the binding ties of costly fuel administration were lessened, offering promise in locomotion, mechanization and electrical generation.

Culture and Technological Change

In *Inside the Black Box: Technology and Economics,* Nathan Rosenberg argues that culture supported and encouraged innovation in Western Europe during its period of industrialization. Rosenberg (1982, pg. 8) that Western Europe possessed "a different kind of rationality;" particularly complementary to the fundamentals of the capitalist mode of production. The willingness of Europe to absorb and apply techniques from foreign social groups, Rosenberg (1982, pg. 12) suggests, contributed greatly to the rate of innovation.

Rosenberg argues that the gradual replacement of institutions favoring the rule of law over the arbitrary whims of an autocratic regime stabilized the perception of risk with respect to innovation. As discussed previously, the decision to innovate takes place in a world of uncertainty. Since there are costs associated with undertaking the effort to improve upon an existing process or to invent an entirely new technique outright – existing processes can always be applied to a familiar problem with a reasonable expectation regarding the outcome – it doesn't seem unreasonable that shaky expectations about the future might dissuade the inventor from taking such a risk.

Philosophy played a key role in creating the cultural backdrop for innovation. As John Dewey,

in *Philosophy and Civilization,* argues that philosophy and culture remain systemically interconnected. Dewey writes:

> "Philosophy thus sustains the closest connection with the history of culture, with the succession of changes in civilization. It is fed by the streams of tradition, traced at critical moments to their sources in order that the current may receive a new direction; it is fertilized by the ferment of new inventions in industry, new exploration of the globe, new discoveries in science. But philosophy is not just a passive reflex of civilization that persists through changes, and that changes while persisting. It is itself a change; the patterns formed in this junction of the new and the old are prophecies rather than records; they are policies, attempts to forestall subsequent developments."

Dewey suggests an active role for philosophy in the process of cultural change. It has been argued by Mokyr (2002, pg. 170) and Rosenberg (1982, pp. 8-12) that variations in religious philosophy determine rates of technological change. Pointing to Lynn White's exhaustive comparison of religions, Rosenberg (1982, pg. 8) points out that Christianity[8] held ideals which were particularly complementary to the needs of capitalism: objectification of labor, parsimony, a world-view that man remains separate and distinct from nature. Most notably, the justification through Christianity – which White terms "the most anthropocentric religion the world has seen" - that humans enjoy eminent domain over all trophic resources on Earth.

Religion aside, Enlightenment philosophers like John Locke and Francis Bacon espoused ideas and values, which were both the cause and reflection of a culture of innovation. Institutions such as private property, protection by law, enforceable contracts, free inquiry and enterprise serve to form customs within a market paradigm.

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[8] White's Historical Roots of Our Ecologic Crisis, contrasts Christianity, ancient paganism, and pan-Asian religions.

In a social system organized around market institutions and a culture which attaches ownership to innovation, innovation then becomes more than just the means to the end of an improvement, but rather an end of its own as a profit making endeavor. Indeed, culture develops artifacts which display its symbols of virtue; in the case of the Industrial Revolution we have the yeoman tinkerer. This heroic archetype beams the values of market success: ingenuity, boldness, craft, and thrift.

Our task remains to gain insight into the role of innovation in a modern market economy. This section has sought to place innovation in an historical context, focusing primarily on the Industrial Revolution. While this only begins to tell an interesting story about innovation, we have seen that change in knowledge through the innovation of technique can never be reversed. The continuous dance between the known set of useful knowledge and techniques which utilize such knowledge can become unstable, and a virtuous cycle in knowledge generation amplifies to break free from the punctuated equilibria of the previous period.

As applied to the Industrial Revolution, the relationship between propositional and prescriptive knowledge can be divided into two phases: Before and after 1800. Prior to 1800 innovations suffered from narrow, albeit widening epistemic bases. Following the amplifying effects of the Enlightenment on the set of propositional knowledge, along with lower access costs, more macro-innovations emerged to provide a basis for ongoing micro-innovation. A positive feedback cycle between useful knowledge and innovation set off a dramatic explosion in technological and cultural change.

Part 2: Social Structures of Accumulation and Innovation

Consistent with the larger theme of this study on the dynamic aspects of innovation in an economic system, we must account for the change in the innovation process over time. The causal feedback between culture and technology implies a continuous process of co-evolution. As technology changes so does culture in a manner consistent with both the history of the previous relationship, but the emergent state as well. Therefore, the processes that allow for the diffusion of innovation through the economy at present are quite different than the process of a time absent of the new innovation. We may then imply that with each subsequent innovation, diffusion leads to an increased level of systemic complexity regarding the processes linking innovation to the market as a need to reconcile the impact of new technology with old.

In a market system uncertainty about the future necessarily affects innovation. The process of production for the market requires the investing entity to subject some portion of its balance sheet to the immediate liquidity needs necessary to finance the wage bill and inputs *before* the gains of production from revenue as a compensating asset. One consequence of the Industrial Revolution was that an increasing share of the economy consisted of large scale, capital intensive industries. Production on an industrial scale requires significant outlays of capital as well sophisticated, integrated markets for products from the basest of raw inputs to refined finished good. Before a cent of profit may be realized the entire process must be financed either through retained profits or credit, which places the firm in the position to validate debts as they come due with revenues or stocks of money.

The decision to invest in the development of new technology weighs against perceptions of one's ability to meet liquidity requirements in the future. The level of liquidity preference becomes more important as the period between investment and return are increased, due to the capital and time

requirements to bring about a new, sophisticated technique. The needs of advanced capital must be met by an accommodation in institutional organization capable of planning for its development and commercialization. John Kenneth Galbraith shows in *The New Industrial State* that technological innovation produces a tendency toward increasingly complex techniques and tools, which large organizations best accommodate. Galbraith (1967, pg. 49) forcefully links the size of the firm to the advent of technology:

> "...Size is the general servant of technology, not the special servant of profits. The small firm cannot be restored by breaking the power of the larger ones. It would require rather, the rejection of the technology which since earliest consciousness we are taught to applaud. It would require that we have simple products made with simple equipment from readily available materials with unspecialized labor. Then the period of production would be short; the market would reliably provide the labor, equipment and materials required for production; there would be neither possibility or need for managing the market for the finished product..."

While Galbraith's observation remains obvious, the implications are quite important. Innovations resulting in a shift of production to capital intensive goods require a tremendous commitment of time during which liquidity is surrendered. The need to plan arises in order to mitigate the retarding effect on investment due to the perception that a risky, uncertain world will render the firm unable to obtain the liquidity necessary to validate liability structures in the future[9]. Planning can

[9] Hyman P. Minsky, in "Stabilizing an Unstable Economy" argues that firms make investment decisions based upon their ability to have the stocks or current inflows of money necessary to cover the same period's outflow. Therefore, the risk that an asset might lose value such that the liquidity necessary to "validate" the liability which generates the outflows falls short. If credit cannot be obtained, then the asset is sold and debt-deflation crisis emerges. In Part Four we shall go into further detail regarding this approach and establish a linkage to innovation.

only be effective at a scale of organization on the level of the modern corporation or the state. Furthermore, the organization must plan for the development of a market for the good. The commitment of considerable capital to the development of new product, with a long production period, serves not current but future demand.

This section how the process of industrial innovation requires an institutional arrangement that stabilizes perceptions of risk and promotes planning. We shall introduce Social Structure of Accumulation Theory as a framework for understanding periods of relative stability with respect to the conditions amenable to major investment in new capital formation. We attempt to show that SSAs serve as an *expectation-fixing* force on the determination of subsequent innovation, enabling planning processes. Furthermore, we discuss path dependence as a feature of SSAs and an *expectation fixing institution*. Finally, we attempt to establish a fundamental relationship between planned market activity against the institutional nexus of a social structure of accumulation. It shall be argued that planned production for the market contributes significantly to the determination of path-dependent innovation, and that the resultant "paths" serve to stabilize the financial aspects of the SSA.

Social Structure of Accumulation Theory

In *Contemporary Capitalism and its Crisis: Social Structure of Accumulation Theory for the 21st Century*, Terrence McDonough, Michael Reich, and David M. Kotz (hereafter MRK,2010, pg. 1) define SSAs as an effort to reconcile long-way cycles of capitalist growth with institutional change. SSA theory attributes distinct periods of accumulation and stagnation to an holistic arrangement of institutional factors, which provide periods of relative stability. Such factors include legal frameworks established in accordance with the rules governing jurisprudence. Future decisions are based on earlier decisions, thereby carrying forward relics of history and placing them in the common

experience.

Organized bodies of legitimate power serve as institutional control measures. For example, official state governing bodies create agendas which establish funding priorities in an ongoing effort to shape the course of investment. Private institutions ranging in influence from the local grange to the US Chamber of Commerce, seek similar agendas and investment priorities.

Moreover, the particular network of institutional factors which constitute the SSA break down over time, giving way to a period of stagnation and the dissolution of that particular structure. As the market undergoes a new period of expansion and accumulation, a new SSA emerges to carry on in a new period of relative stability.

McDonough et al (2010, pg. 2) explain that SSA theory rises from the need to reconcile some key insights from Marxian and Keynesian macroeconomic approaches. In the former, McDonough et al (2010, pg. 2) suggest that the Marxian theme of class conflict, most notably the struggle for power between labor and capital, create uncertainty regarding the determination of profits.

SSA's Keynesian roots center on the importance of uncertainty. Keynes (2003, pg. 285) stressed that expectations regarding the future determine the level of output and employment. We can conceptualize this operationally by considering that, as Wray (1990, pg. 10) points out, money plays the role of unit of account. It has been argued extensively by PK[10] monetary theorists that money cannot be neutral due to the fact that production must be financed in money denominated debts, subject

[10] We shall offer a comprehensive treatment of the PK conception of money in the next section. Chief proponents of this approach include Basil Moore, L. Randall Wray, and the late Hyman P. Minsky. Additionally, Schumpeter can be associated with the endogenous money approach due to his recognition that innovations must be financed out of credit, since existing money flows were just sufficient to satisfy the existing circular flow of goods. This point is made in The Theory of Economic Development.

to changing conditions in terms. An increase in liquidity preference results in insufficient levels of effective demand. With liquidity preference determined by uncertainty institutional arrangements that have a limiting effect stabilize conditions for investment. MRK (2010,pg. 3) suggest:

> "When a social structure of accumulation is in place, many of the determinants of the profit rate are secured, and long-run expectations of profitability are stabilized."

The Marxian theme of class conflict as an internal contradiction fits nicely as a determinant of the profit rate in question, thereby linking it to the Kenyesian problem of uncertainty. Coupled with the requirement to stabilize expectations regarding investment over a long period – where retained profits or credit are required to finance innovation – SSA theory serves to explain how institutional arrangements limit the destabilizing aspects of economic change.

Victor Lippet (2010, pp. 45-6) further defines SSA theory by explaining how institutions limit perceived risk. Institutions – broadly defined to allow for customs, norms and habits of thought, while retaining the narrow case of the individual organization[11] - that work systemically to favor investment serve as SSAs. As Lippet (2010, pg. 46) carefully disclaims, deductive proof of the stabilizing function of SSAs is not possible. However, we may apply this framework to distinct periods of capitalist growth. Looking at what SSA theorists (1996, Gordon, Weisskopf, and Bowles)[12] describe as the *Post-War WWII SSA* we can see the stabilizing effect on profit expectations of the capital-labor accord. In economic history, the capital-labor accord describes the post-war peace between labor and

[11] Institutions in the narrow sense may have a well defined effect on the broadly defined institutions of norm, custom and habit. For instance, the financial system can be thought of as in institution by which the whole of money convention rests. Norms relating the human experience to customs involving money must be reconciled in the cultural sense in terms of the Federal Reserve, Treasury, and the intermediary banking super-structure.

[12] Courtesy to Lippet (2010, pg. 48) for the reference.

capital. In exchange for fringe benefits, stability and cost of living pay increases labor would not strike and the threaten the largest corporations with lost productivity. In exchange for higher labor costs owners of the commanding heights of the economy enjoyed a period of stable expectations. Lippet (2010, pg. 50) elaborates on the importance of the *capital – labor accord* in limiting risk:

> " The capital-labor accord addressed one of the central contradictions in capitalist economies...capital can be 'too strong' or 'too weak' relative to labor. If capital is too strong, wages will be kept down, but that in turn threatens the maintenance of aggregate demand, leading to a potential crisis of under consumption. Profits will be high in production, but sales will be curtailed by limited purchasing power, discouraging new investment. On the other, if capital is too weak high wages will limit profitability by raising production costs..."

The balance of power between capital and labor proves useful as an example of the stabilizing benefit of the SSA if we remind ourselves of the nature of innovation of technology, advancing in technological complexity, in a market economy. Galbraith's[13] revelation that the long production period and high capital requirements of progressively complex technology requires planning, provides a background against which to place the importance of the capital-labor accord in supporting the *Post-WWII SSA*. The ability to limit the riskiness of an investment by fixing, albeit loosely, the determinants of cost, then the firm may make a calculated bet against the future. Likewise, the dominance of the modern corporation in relation to the market allows for fixed expectations through the administration of prices.

In an effort to establish a heterodox price theory, Fred Lee presents a model of *pricing* for the market as *administered* by the modern business enterprise. Lee (1996, pg. 88) argues prices are

[13] Quoted passage from New Industrial State

administered by firms run by individuals or managerial committees. Lee suggests that established procedures or processes that determine cost, depreciation, and output are administered by the managers of the firm to the market. Furthermore, these procedures must comply with the institutional framework set legislation. Laws which change how the existing tax structure affects the production process must be factored into the price administration of firms.

The effect of price administration mirrors that of the cost stabilizing techniques, such as the capital-labor accord, and allows for coherent planning. The ability to reliably administer prices and set costs, allows the firm to predict its liability structures in the future, a critical determinant of liquidity flows. Lee (1996, pg. 90) suggests that prices are set for periods of time based upon a production cycle under which the inputs are financed. Furthermore, prices change over time as the cost of production changes.

The ability of the firm to finance investment activity depends upon its size, power and access to liquidity. As Hyman P. Minsky (1986, pp. 171-2) clearly lays out, firms must rely upon retained profits or lines of credit to finance investment, since the revenues attributable to the resulting production process from the investment flow exist only in the future, potentially. While a stream of revenue may result from the investment commitment, the current wage bill must be met with an existing flow of liquidity from any annuity. In the event that a firm wishes to embark upon a lengthy development of a new process or product, one which lacks an existing market, they must do so in a manner which minimizes the risk that the gains to commercialization of the innovation fail to outweigh the cost of commitment of a new liability structure. It follows that as technology increases in capital intensity, its diffusion requires a rather organized structure of planning and finance.

Path Dependence, Investment and Innovation

In a market economy, inter-temporal flows of credits and debits are determined by the annuities of both assets and liabilities. Contractual payment agreements based upon the expectation of future income generated by production yields are sensitive to the risk that the underlying asset might fail to maintain the stream of payments necessary for its validation. Therefore, investment which results in path-dependent development, tightens the expectation that the stream of revenue generated will validate the associated liability in the appropriate period. We further define path-dependence and work to place it in context with the focusing aspect of social structures of accumulation.

We find in path dependence the "unifying principle" needed to focus an emergent SSA. As an institution, path dependence in any form that affects the flow of money over time may provide stability to the SSA. Paul David's seminal contribution of *Clio and Economics of QWERTY* on the theory of path dependence provides an analytical framework for understanding the innovation process within the milieu of a social structure of accumulation. David (1985, pg. 332) argues the outcome of any particular process may be heavily influenced by a non-local event(s) in time. The decision to invest in one novel process over the other, especially one tied to a liability position in production finance, would qualify as influential to the future course of investment decisions. When the diffusion of innovation requires such a considerable level of capital, technology notwithstanding, a divergent subsequent innovation proves costly.

David (1985, pg. 332-6) explains that the QWERTY keyboard arrangement emerged as an engineering solution to the tendency for type-bar machines to jam when the end user typed too fast. Additionally, the arrangement allows for the salesman to peck out the word "typewriter" using only the top row, reducing the likelihood that the demonstration might fail to impress the client. As improvements in the design of the typewriter relaxed the physical constraint on typing speed,

competing designs emerged. Despite the promise of enhanced efficiency and a more productive clerical labor force, the QWERTY arrangement persists today due to self-reinforcing mechanisms that approach an asymptotic state of "lock-in." This mechanism implies a degree of cost associated with the decision to adopt an non-complementary standard to the prevailing technology that approaches the path-dependent state.

David (1985, pp. 334-6) points to a range of costs associated with deviating from path dependent innovation. The decision of a firm to purchase typing machines with the QWERTY configuration creates a positive externality for the QWERTY trained labor force. The fact that individuals need no retraining on operation of the typewriter, lowered the cost of adopting QWERTY rather than selecting a different configuration. This early advantage carries a cascading effect on an ever increasing probability that QWERTY keyboard will be selected in the future. We may extend this example to say that markets integrated with a path-dependent production process provide a further positive externality to any subsequent innovation that proves complementary. The self-reinforcing mechanism of "lock in" eventually approaches unity with respect to the probability that a future innovation will complement the established path. The call and answer between a path-dependent innovation and complementary adaptations, always emerging in response, can be thought of as a process of co-evolution.

In an effort to bring the economy – *a complex, evolving system* – into a realm of analysis suitable for explaining the dynamic nature of change, W. Brian Arthur (1988, pg. 209) argues that *self-reinforcing mechanisms*[14] create "a multiplicity of asymptotic states or possible *emergent structures*."

[14] Arthur refines his definition of self-reinforcing mechanisms by offering a host of synonyms that describe the same process: increasing returns;

Positive feedback loops create emergent market structures that have outcomes along path-dependent, asymptotic "lock-ins" as a result of conditions in the early phases of its development.

Arthur (1988, pg. 210) suggests four likely causes for a state in which economic structure undergo processes of self-reinforcement. First, and most notably, the large-scale capital requirements of industrial production, wherein economies of scale generate a negative relationship between unit cost and output. The increasing returns to scale inherent of large scale, organized production introduce a selection bias favoring concentration among producers in the market. In order to validate the liability structures associated with production on the scale that makes possible increasing returns, a significant share of the total market is required for each firm. This introduces barriers to entry on the part of latecomers or small firms, that cannot capture significant share of the market to facilitate production on a scale that would generate sustained accumulation.

Arthur (1988, pg. 210) adds that learning and coordination effects, as well as adaptive expectations each account for the presence of self-reinforcement. It is worth our time to cover some of these aspects in further detail. Arthur (1988, pg. 210) accepts the argument by Arrow (1962) and Rosenberg (1982) that learning effects serve to lower the cost of production of a given good through innovations in production technique, thereby increasing the likelihood that the good viz-a-viz substitutes will be selected in the market. Furthermore, learning effects attributable to continued replication of a given production process may result in product improvements, increasing the probability that its market shall remain.

Along similar lines of reason, coordination effects, suggests Arthur (1988, pg. 212), create

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cumulative causation, deviation-amplification mutual causal processes; virtuous and vicious cycles; threshold effects; and non-convexity.

network externality that induce the "going along" effect in selecting diffusion patterns. The benefits that accrue commonly among widespread adopters of a path-dependent tool, technique or process spring from a "self-fulfilling prophecy" effect based upon a mutual expectation between consumer and producer. In order to better demonstration the impact of coordination effects, let us examine a few case examples where such effects yielded a path-dependent outcome in relationship to the determination of subsequent innovation and the flow of investment.

The development of the railroad in the United States serves as a representative innovation under conditions of self-reinforcement. First, the large-scale, capital-intensive nature of the railroad implies increasing returns to scale. From 1839 to 1860 the extent of railroad networks throughout the economy explodes from three to thirty thousand miles; a flow of investment to railroads over canals at a rate of 500%[15]. As the railroad spread through the economy, regions would benefit from the coordination effects of selecting complementary standards in railroad construction.

Old localized track gauge standards, while once the result of an earlier "lock-in" to one of many equilibria, require a significant outlay of commitment of liquidity to adopt a different standard. Mokyr[16] explains that despite the relative independence between rail lines, where some owned as much as one thousand miles of track based upon a proprietary gauge, the increasing extent to which the railroad was responsible for the transportation needs of the market overcame the cost of switching track gauge. The cost according to Mokyr was indeed dear: in a coordinated effort, the Illinois Central shut down normal operations on July 29, 1881 just long enough for a ready army of labor – a crew of three thousand – to modify the track gauge along five-hundred forty-seven miles of the line. The maneuver

[15] Source: Joel Mokyr, "Railroads and Nineteenth-Century American Economy

[16] Ibid pg. 430

successfully completed within the span of a single day!

We have shown that self-reinforcing forces steer the flow of investment towards path-dependent processes and institutions. The expectation-fixing quality of an investment good, namely its ability to lower the perception of risk, acts as a focusing device, a lever of influence on the formation of institutions which together support a network of interdependence and stability. Social structure of accumulation theory, frames the emergent phenomena that over time form the basis for the expectations necessary to induce investment, capable of organizing the planning necessary in order to meet established goals. The nature of innovation under these conditions becomes one of "lock-in" to path dependent states of punctuated equilibrium[17].

This analysis has sought to integrate the role of money as a fundamental element of the social structure of accumulation. Of central concern to the financier is the health and condition of the balance sheet under which production is financed. The need to finance out of credit the necessary outlays for the level of capital formation that is sufficient to result in an economy of scale, suggests that the course of innovation in production processes must remain complementary to the underlying asset that continues to validate the liability structure. In other words, investment tends to flow towards the development of new techniques, products, and processes that *reinforce* the expectation that revenue from future operations will continue to retire debts as they come due. In Part 4 we develop in greater detail a framework by which we can place innovation in a monetary system of market production. Yet for now, we proceed to our analysis concerning innovation and social change.

[17] Stephen J. Gould

Part Three: Innovation and Social Change

To explain the evolution of social systems requires a thoughtful consideration of the processes which shape institutional innovation. The objective of this inquiry remains to establish a framework wherein innovations in the realms of technology and of social structures, that direct the employment of these ever changing material artifacts, connect to steer the course of human development, and the subsequent creation of new conditions.

This section presents a model for social change which rests upon the philosophical insights of the eminent pragmatist philosopher, John Dewey. Dewey insightfully presents a mode of inquiry appropriate for complex, dynamical systems. The choice to employ Dewey as an intellectual guide in this analysis stems from the recognition that as an open, evolutionary system of social provisioning, observation of the forces of change acting on market processes must come from within. Dewey's insistence that social problems be studied from a perspective of process has produced a number of valuable insights which provide the basis for our evolutionary paradigm.

Dewey in *The Quest for Certainty* explains that the Greek mode of rational formalism[18] persists in modern science and philosophy, despite its lack of relevance in light of the discovery of evolutionary processes yielding in outcomes dependent on historical conditions[19]. An ontology based upon pure and

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[18] Dewey predicates this argument on the assumption that the whole of Greek thought and mysticism lie in the search to explain the stars as they were heavenly bodies in the sky. The celestial ideal of these heavenly bodies becomes one of perfect motion in unity. Immutable states of perfect equilibrium.

[19] This excerpt from The Quest for Certainty serves as the first part of the second chapter titled, "The Great Philosophic Separation" in Joseph Ratner's reader John Dewey's Philosophy. This work was part of the Modern Library collection, circa 1939.

immutable forms, the attainment of which becomes the ultimate human endeavor, reflects what Dewey suggests as "systemizations in rational form of the content of Greek religious and artistic beliefs."

While this study avoids approaches which aim to establish a model for equilibrium, which hails from the Greek tradition, further consideration of Dewey's critique helps establish some background for reflection on the problem of institutional innovation and course of future development Dewey (1939, pg. 287) on the development of the Greek tradition offers: "the belief that the divine encompasses the world was detached from its mythical context and made the basis for philosophy, and it became also the foundation of physical science." Dewey goes on to point out that "telling the story of the universe in the form of rational discourse instead of emotionalized imagination signified the discovery of logic as a rational science[20]"

Logic, therefore, emerges as an example of institutional innovation. It arises as a new technique in philosophical inquiry. As an institution, logic provides a focusing lens on the generation of potential, future knowledge. The application of logic against the reflections of experience codifies the results in a way that carries information about the past, and provides a basis for fixing mutually held expectations throughout the social nexus. Furthermore, the evolution of institutions through time, constrained by conventions based upon logic, produces adaptations toward a scientific end.

Following Dewey, it shall be argued that institutions change under processes that typically exhibit path-dependent outcomes. Innovation of institutions heavily depends upon the influence of prevailing, initial conditions which are shaped by historical conditions and outcome of previous innovations. Moreover, institutions serve to filter and focus the information that flows through social networks, the basis for subsequent diffusion of innovation. Therefore, social change through

[20] Ibid

institutional innovation remains constrained by path-dependence and suggests a high degree of positive feedbacks within the system. Since the market operates based upon conventionally held expectations, we must examine how these conventions emerge and persist. Paul David (pg. 205) argues that institutions serve as path-dependent *carriers of history*. Through institutions the past is preserved and continues to exert an influence over the course of future innovation.

This analysis proceeds with the argument that emergent phenomena resulting in institutional change, must reconcile with the constraints of path-dependence as it relates to the extant set of conditions. Therefore, the course of innovation reflects a persistent rigidity in culture, attributable to self-reinforcement of social conventions. We begin with a consideration of David's application of path-dependence theory to institutions.

According to David (pg. 290) systems possessing path-dependent processes suggest the presence of "non-ergodicity." Simply defined, non-ergodic systems consist of processes that yield a stochastic probability distribution sensitive to time. In other words, the likelihood of predicting the future in the absence of historical information, based only upon current conditions as explanatory variables, is impossibly low. David suggests:

"systems possessing this property... are unable to shake off the effects of past events and do not have a limiting, invariant probability distribution that is continuous over the enter state space."

In plain terms, the events of the past play a direct role in forming the probability distribution at any given time of a stochastic process. As time progresses the outcomes of each iteration depend more on the consequences of previous iterations. Thus, institutional innovation acting as force for evolution within the system, drifts toward a path-dependent outcome.

An analogy here might serve useful in our effort to drive home the importance attributed to non-

ergodic systemic change. Imagine a river flowing through time. Let us suggest that the river meanders, alternating in a serpentine pattern across a flat floodplain. At the closest scale of observation manageable, we clearly see that suspended in the water, sediments float downstream as long as the flow remains stable. Since the velocity of the flow is a function of the radius from the center of the bend and the extent of the river, water flows slower closer to the inside of the bend relative to the outside. This arrangement causes two things to happen simultaneously: 1) sediments to fall to the river bed near the bank and 2) bank cutting by faster flows on the outside.

If we let time take on discrete segments as process iterations then we can see how the river illustrates path-dependent change. With each iteration the probability that sediment falls or floats depends increasingly on the outcome of the previous iteration. As the river drops sediment in one instance it skews the probability distribution of the next iteration to favor the chance that similar sediment will carry the trend. The far side evolution mirrors the near side just described, in that each time sediment is carried away it increases the likelihood that the same will occur in the future. It has eroded away sufficient material to increase the radius of the turn, thereby increasing the flow.

If we reversed each iteration, like peeling back the layers of an onion, we might find the once straight river began the process of meandering flow from the minor obstruction of a rock in the stream. The chance that the river will alter its direction of flow, ever so slightly to trigger serpentine flow, is much like the "accidents of history" that provide the early conditions to trigger self-reinforcement in investment.

While the literature on path-dependence typically focuses on explaining why investment favors a particular set of procedures, techniques or tools in the production of a good for the market, David (pg. 291) readily extends the theory to explain similar phenomena in institutional innovation. David (pg.

219-292) argues that institutions guide individual behavior through conventionally held, mutually consistent expectations. Furthermore, conventions follow a path-dependent course of innovation due to their inherent need to stable expectations among a network of uncoordinated, dispersed agents. Decisions by individuals are made in light of new information, yet shaped, constrained and formed by the conventional wisdom of mutually consistent expectations. For David (pg. 291) conventions align the expectations of a collective soup of individual agents along a mutually consistent lexicon of understanding. While David applies this relationship to the problem of coordination games, we extend this simple observation as a general pattern in the formation of networks connecting individuals within groups.

The nexus of conventions of various degree and importance carries through time information which describes the relationship of the individual to the group. Moreover, these networks of conventional wisdom (e.g. mores, habits of thought, and customs) provide structure to pathways of information flow within and between groups. As institutions evolve, the network in which institutions exist adapts, necessarily changing the way information diffuses through the social nexus.

Networks perform a number of functions in the social system. First, they connect the individuals within a group and allow the broadcast of information both at individual and collective levels of experience. In the former, individuals reflecting upon personal experience may transmit such information to the public sphere. The latter of course provides the basis for reflection against which mutually consistent expectations provide structure to individual decisions.

Second, networks serve to shape the flow of information through the social system. Due to technical, physical or institutional constraints the diffusion of new information through the network tends to exhibit a bias towards information that is best suited for transmission through the network.

This brings forth a rather important implication regarding the nature of innovation among social institutions. Established networks along groups of individuals that interact together in a larger social system, are further reinforced by the relative ease with which institutional innovation is supportive of the existing order flows through the network.

The abstract nature of institutional innovation as an iterative process of information diffusion through social networks, benefits greatly by rooting the implicit theoretical constructs in real world examples. Let us suppose that a little league baseball game sets the stage for a simple network. Networks emerge as the potential pathways for the exchange of information between the individual and group. As the proud parents of the little leaguer participate in the social activities generally associated with such an event – cheering, conspicuous consumption, side conversation, physical expression – there exist a number of processes underway which account for the function of the network. In accordance with custom and convention, parents communicate information regarding their experience of the event to the rest of the group by way of the network. Cheering is heard by others in the immediate vicinity. Since cheering carries the precedence of acceptance, and is generally complementary of the network that transmits the inherent information, then its subsequent diffusion through the network reinforces the convention. Additionally, the network remains constrained by the physical constraints implied by geographical coincidence. In order for the network to emerge, the parents of these child athletes must collect in a common location. The network associated with the little league game, therefore only exists during a game.

Observation of common modes of conveyance yields further insight into the geographical nature of some social networks. When vehicles drive down the freeway a network emerges that connects the individual driver with a larger group of drivers, through the relay of observed billboards.

Again, the network is physically constrained by the geographical limits of billboard placement around a freeway, the speed of travel along the highway, and conventional wisdom held to be mutually consistent within a group of drivers. Hence, information in this network tends to flow unilaterally, as drivers must passively consume the information conveyed by the billboards due to the obvious limits of operating a motor vehicle. The mode of "broadcast communication" where information predominately flows through the network, where immediate critique and response is limited or non-existent, implies a degree of asymmetry in institutional innovation, which biases subsequent changes in the network towards information inherent in the existing order. In other words, the information broadcast in roadside advertisements is selected not based upon equilibrating forces selecting information on the basis of meaning or importance, but the whims of a powerful vested interest in the social structure of accumulation.

One implication of path-dependent evolution in social institutions is the possibility that some or certain groups become more powerful than others over time. Recent research in the science of social networks suggests a high degree of asymmetry with respect to power and influence, which serves to reinforce divisions between groups and place some in position of higher influence than others. Nicholas Christakis and James Fowler employ social network analytical techniques to analyze the effect of group dynamics over time. Christakis and Fowler (2007, 2008, 2009) find that individuals acting as "central nodes" exert influence through the network, up to an average of three degrees of separation. Moreover, central nodes have a higher than average likelihood of influencing the behavior of non-central nodes, suggestive of self-reinforcing dynamics.

While contributions of Christakis and Fowler focus on explaining how seemingly personal decisions regarding health (smoking, poor diet, etc) spread

through social networks, they insist that dynamical network analysis applies to a wide range of social phenomena, including the innovation of institutions over time. Fowler and Jeon (2007) apply network analysis in an effort to explain the evolution of Supreme Court decisions over time. Using a sample of 30,288 majority opinions from the bench, a network connecting citations between 1754 and 2000 shows a pattern of *stare decisis*. According to Fowler and Jeon (2007, pp. 16-29) legal institutions evolve in a manner that reinforces *stare decisis*, latin for "stand by decisions." Courts honor the majority decision of a case, which serves to lock the law into a state of legal *path-dependence.*

The rigidness implied by institutional "lock-in" in legal precedence suggests that over time, asymmetrical effects of the law across the network with respective to the distribution of power, may become institutionalized. In the capitalist system of monetary production, money flows through nodes of central influence established by institutionalized and asymmetrical legal protection. Similarly, relative influence depends upon access to money, creating a mutually reinforcing relationship.

Part 4: Innovation and the Monetary System of Production

Previous sections of this analysis claim that money serves as a determinant in the process of systemic evolution. Money possesses special properties that establish its dominance in relation to other institutions within the economic system. First and most importantly, money performs the task of linking the future with the present in terms of the material goods of society through the establishment of contracts. The use of contracts in the functioning of a market system based upon private property is so ubiquitous it hardly warrants mention. However, the recognition that money performs the duty of the contract instrument - *the job of linking the future with the present* - remains a profound revelation, that any theory that seeks to reconcile money and real production should not overlook.

The use of contracts ranging in formality from an informal handshake to formal, legally binding agreements, arises from the desire to attenuate the risk associated with an uncertain future. When an individual trades some portion of her current income for a contract vehicle that entitles her to a future stream of income, it emerges from the fear that her current income in the future will fail to satisfy some desired level of consumption in the future. Of course, the individual level of risk aversion determines in large part what portion of current consumption flows towards savings. However, in the aggregate varying perceptions of risk on the part of households, firms, and financial institutions determine the level of investment in the economy, *ceteris paribus.*

Uncertainty about the future state of one's material well being is a central problem in economics. L. Randall Wray (1990, pg. 11) observes that fear of the unknowable future is central to Keynes' monetary theory. The liquidity enjoyed by holding cash provides a feeling of safety; fear of the unknown may overwhelm the need to place money in a productive position of investment.

Innovation, Markets, and Evolution

Part two of this paper argued that technological innovation emerging from the Industrial Revolution increased the scale of industry in order to accommodate the needs of large, capital intensive production. Production on an industrial scale increases the period between investment and return to such a degree that the inputs to production must be financed. The establishment of a contract for payment between the banker and the firm connects the institution of money to innovations, by promoting only changes that improve the monetary position of the firm. The banker has little interest in breaking the rents of its chief customers, increasing the risk of default. This section aims to make explicit the link between credit, money and the production process.

This section argues that in a market system of production, money takes on the special role as the institutional guide by which innovations diffuse through the economy. Furthermore, money becomes the subject of innovation itself as it undergoes a process of co-evolution with the market. In support of these claims we adopt the *endogenous money* approach of the post-Keynesian school. The post-Keynesian conception of money presents a useful analytical tool for explaining the behavior of markets under the uncertainty of time. The emphasis on how money flows through an uncertain world integrates with the overall historical approach of this inquiry.

This section sets out to establish the endogenous money approach as an appropriate theoretical tool for explaining production in capitalist markets. Next, we attempt to connect the contractual property of money to the process of innovation and argue the flow of money shapes subsequent evolution of the system. Finally, we examine the mechanisms under which money adapts in response to changes in the institutional framework of the market.

Endogenous Money and the Capitalist Mode of Production

Keynes emphasized the economy as a system of monetary production. Wallace Peterson (1996, pg. 151) argues that in contrast to the premise that money is neutral, Keynes integrates money as an endogenous element of "modern systems of market capitalism," suggesting a non-neutral role. As an embedded institution, money touches every aspect of the production process. Performing the accounting function in a system of private contracts, money becomes an instrument acceptable to settle debts universally (Wray 1990, pg. 8). Therefore, the production process seeks to establish a flow of money for the sake of settling a debts.

Following from the revelation that modern capitalist markets rest upon a system of *monetary production*, the post-Keynesian school analyzes the way money enters the economy endogenously. Wray (1990, pg.14) defines money as:

> "...the terms in which debts are written; it is the unit of account; it is the balance sheet item created as part of a forward contract. Thus, money is a stock created to facilitate flows."

Rather than developing from the barter system, Wray (1990, pg. 9) suggests that money emerges as property is created, as a means of accounting for contractual flows of property through time.

Money and Innovation

Schumpeter, Keynes and chief proponents of the PK monetary approach attribute to the financial system a significant share of the decision to invest. Schumpeter (2008, pg. 74) argues that the banker, "stands between those who wish to form new combinations and the possessors of productive means." In other words, the entrepreneur must submit to the banker in order to integrate an innovation into the production process. Minsky (1986, pg 224) offers that in the modern financial system, banks expand their balance sheets in order to lend for the sake of investment. Furthermore, the firms ability to meet its contractual obligations as they come due, "depends upon the quasi-rents that capital assets

earn when used in production," (Minsky 1986, pg. 224). The relationship between debtor and creditor ultimately hinges upon balance sheet positions in which the creditor exert influences, *albeit indirectly*, over the formation of means of production. Furthermore, as an increasing share of output throughout the economy requires the extension of credit from the financial system, the goals of each entity – producers and bankers – grow together in a symbiosis, each mutually supporting the needs of the other. Minksy (1986, pg. 228) suggests that "because bankers live in the same expectational [sic] climate as businessmen, profit-seeking bankers will find ways to accommodate their customers."

Against the notion that credits and debits flow inter-temporally through the balance sheets of firms and banks, arises the pervasive phenomena of existential uncertainty. As Wray (1990, pp. 8-9) notes, private property destroys the collective safety net of surplus; the future must be secured not by individual rather than social contracts. In each period, the need to ensure a steady flow of quasi-rents or profits dominates the production process, rendering it subordinate to the end goal of accumulating money. With the advent of the large corporation as the dominant institution in the US economy and an integrated network of financiers supporting its hegemony, the manner of innovation as it relates to the social system of production serves to reinforce the status quo, rather than invoke the "perennial vale of creative destruction[21]."

The Evolution of Money

Wray (1990, pp. 2-14) illustrates that money emerges with the institution of private property,it predates markets and serves as the unit of account of essentially a "wheat now for more wheat later proposition.[22]" Money as the contract vehicle for inter-temporal trade of private property, as well as

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21 Schumpeter, Theory of Economic Development

22 Wray uses the analogy of wheat to demonstrate the contractual nature of a market based

claims to the flows of revenue associated with such property, undergoes iterations of innovation. Wray points to Keynes' argument in *The General Theory* that each commodity carries an "own-rate" of interest – or a premium by which the holder parts with some portion of it – and that over time commodities of lowest "carrying cost" emerge to account for the purpose of universal credit-debit clearance. Thus, history shows that money evolves through time to perform the role as unit of account; the universally accepted means of retiring debt. At earlier stages in history, grain served as unit of account, later precious metal, and now credit money based upon state debt.

Money continues to serve as the object of innovation. Minksy (1986, pp. 225-7) argues that bankers constantly seek new instruments which serve the purpose of retiring debt. Due to institutional constraints, such as attempts by the Federal Reserve of restricting the behavior of intermediary banks through interest rate targets, banks come under tremendous pressure to supply the money necessary to validate a complex network of interdependent balance sheets. Moreover, the internal logic of the capitalist mode of production requires an ever increasing supply of money in order to sustain the open process of pecuniary accumulation.

Aside from the systemic need to supply funds for the sake of production and for the validation of maturing debts, there exists a predatory aspect to the banking system that exerts pressure on banks to development new liabilities to issue, thus promoting growth. At the heart of the banking motive lives the desire of the bank managers to accumulate "personal fortunes", a wholly separate function from the traditional purpose of extending credit to credit worthy customers. Minsky (1986, pg. 238) argues:

"The typical professional bank president is not a rich man when he starts his career. As a bank president

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upon private property, where risk premiums associated with the uncertainty of lending "wheat" to another individual account for the time lapse in which the wheat is no longer immediately available to the lender. The contract in wheat becomes a debt which takes on the properties of money.

> he is a hired hand trying to achieve a personal fortune. But given the tax structure, it is difficult to accumulate a fortune by saving out of income; the most efficient route for a business executive is by way of stock options and the capital gains that accrue as the stock market price per share rises. As holders of stock options, bank management is interested in the price, on the exchanges, of their bank's shares."

In the banking sector the price of a stock depends highly upon the size of the bank in terms of market capitalization and coverage. The larger the bank, the higher the price. Bank managers wishing to maximize individual hoards of money, promote activities which increase the balance sheets of their financial institutions.

Conclusion

Throughout this study we attempt to establish innovation as a function of an evolutionary social system. Groups of individuals form networks that organize and direct the productive activities of the social system, shaping the emergent state in a manner complimentary to the existing order. We set out to reconcile innovation - as it relates to a complex, dynamical system - with the structure of the very networks that embed each institution in an interdependent social fabric. Like a thread, the institution of money weaves through the social system, connecting groups and individuals in a global market.

Social network analysis in the fields of medicine and computational social science suggest "nodes" of power and influence scattered throughout the social system, which act as relays in the transmission of information, most notably cultural signals. To act as the node implies a degree of centrality in one's personal relationship network. Not all agents in the network are created equal in terms of power. Rather, influence within the network reinforced and magnified by self-reinforcing mechanisms common to evolutionary systems. In our social system of monetary production, money's role as the unit of account by which all debts are settled, only strengthens its power over time.

We framed our analysis from an historical perspective to highlight the interplay between the extant and emergent system states. Veblen's "habitual method of procedure" refers to the *extant* structure of the system; the rigidness of path-dependent institutions. The emergent arise from the material consequences of historical developments. The bias in probability to the sort of change in institutions and technology that preserves historical procedures provides rigidity to the system. Path dependence in all manner of innovation gives structure to the social system. Thinking about the economy as part of a social system that evolves through *historical* time highlights the irreversible nature of change. So called, "accidents of history" determine in large part the long-term path of

innovation. Path-dependence literature suggests that a system can "lock-in" to an arbitrary vector of evolution. The past persists in the memory of the system; some institutions and techniques persistent through history.

The institution of money arises from the emergence of private property. We argue that in a social system that relies on markets as its production and provisioning mechanism, money ties all elements of the system in one common network. In systems of production where discrete segments of time require payment in money on debts, pecuniary gains become the end of society; money becomes the subject of innovation.

This paper has emphasized the process of change. Starting with the Industrial Revolution we begin to tell a story about the continuous nature of change in the economy. We adopt Mokyr's knowledge which describes a feedback between propositional and prescriptive knowledge. The Industrial Revolution can be described as an explosive period in innovation, where major breakthroughs in science were met with ingenious application to the physical world. Mokyr's frameworks suggests that the relation of propositional to prescriptive knowledge post 1800 set off a positive feedback in innovation – some innovations caused the base of propositional knowledge to increase, further increasing the chance of an addition to the set of prescriptive knowledge. The telegraph comes to mind as a technological change that extended access to more individuals the real of science.

Consequential to the tremendous investment in fixed capital during the Industrial Revolution we have an increase in the need for organized economic planning. Galbraith makes the point, as the "...Size is the general servant of technology" which increases the need to prepare the market for production. Planning becomes necessary in order to stabilize profits versus costs, and to prepare the market for future consumption.

This analysis has argued that SSA theory presents a powerful analytical tool for explaining the nature of organizational planning for market production. Furthermore, we propose that path-dependence serves as an *expectation-fixing device* – a cultural artifact that smooths expectations regarding the volatility of the future. Out of an evolutionary framework we view the social system of production as fluid, yet sometimes viscous, but always changing. By taking the long view on the subject of economic change, we see the effect of power and tradition in the application of Homo sapiens' most unique trait: the power to bend our constraints just a little further in an act of defiance against the odds of extinction. And through the recognition that convention and social pressure shape the course of our collective efforts to persist, we hope to approach the problem of social policy informed, and ready to innovate.

Bibliography

Christakis, N. A. and J. H. Fowler. 2008. "The Collective Dynamics of Smoking in a Large Social Network." *The New England journal of medicine*, 358(21), pp. 2249-58.
____. 2007. "The Spread of Obesity in a Large Social Network over 32 Years." *The New England journal of medicine*, 357(4), pp. 370-9.

Dewey, John and Joseph Ratner. 1939. *Intelligence in the Modern World; John Dewey's Philosophy*. New York: Modern Library.

Fowler, J. H. and N. A. Christakis. 2008. "Estimating Peer Effects on Health in Social Networks: A Response to Cohen-Cole and Fletcher; and Trogdon, Nonnemaker, and Pais." *Journal of health economics.*, 27(5), pp. 1400.

Galbraith, John Kenneth. 1967. *The New Industrial State*. Boston: Houghton Mifflin.

Hall, J. and O. Whybrow. 2008. "Continuity and Continuousness: The Chain of Ideas Linking Peirce's Synechism to Veblen's Cumulative Causation." *JOURNAL OF ECONOMIC ISSUES*, 42, pp. 349-56.

Lippet, Richard B. 2010. "Social Structure of Accumulation Theory" In *Contemporary Capitalism and its Crises: Social Structure of Accumulation Theory for the 21st Century*, ed. Terrence McDonough, Michael Reich, and David Kotz 45-72. New York: Cambridge University Press.

McDonough, Terrence; Michael Reich and David M. Kotz. 2010. *Contemporary Capitalism and Its Crises : Social Structure of Accumulation Theory for the 21st Century*. Cambridge; New York: Cambridge University Press.

Minsky, Hyman P. 1986. *Stabilizing an Unstable Economy*. New Haven: Yale University Press.

Mokyr, Joel. 1985. *The Economics of the Industrial Revolution.* Rowman & Littlefield.

____. 2002. *The Gifts of Athena : Historical Origins of the Knowledge Economy*. Princeton [N.J.]: Princeton University Press.

____. 1992. *The Lever of Riches : Technological Creativity and Economic Progress*. New York; London: Oxford University Press.

Rosenberg, Nathan. 1982a. *Inside the Black Box : Technology and Economics*. Cambridge [Cambridgeshire]; New York: Cambridge University Press.

____. 1982b. *Inside the Black Box : Technology and Economics*. Cambridge [Cambridgeshire]; New York: Cambridge University Press.

Schumpeter, Joseph A. 1983. *The Theory of Economic Development : An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. New Brunswick, N.J.: Transaction Books.

Veblen, Thorstein. 1998. "Why Is Economics Not an Evolutionary Science?1." *Camb. J. Econ.*, 22(4), pp. 403-14.

von Tunzelmann, G. N. 2000. "Technology Generation, Technology Use and Economic Growth." *European Review of Economic History*, 4(2), pp. 121-46.

Whalen, Charles J. 1996. *Political Economy for the 21st Century : Contemporary Views on the Trend of Economics*. Armonk, NY: M.E. Sharpe.

Wray, L. Randall. 1990. *Money and Credit in Capitalist Economies : The Endogenous Money Approach*. Aldershot, Hants, England; Brookfield, Vt., USA: E. Elgar.